U. S. DEPARTMENT OF AGRICULTURE

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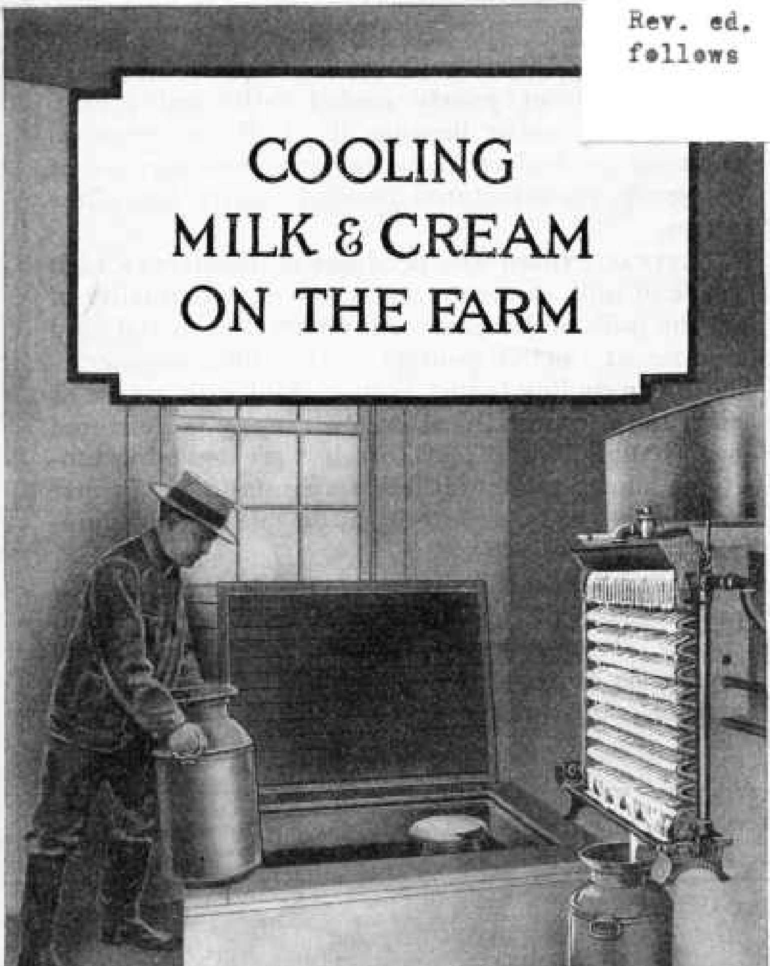
COOLING MILK & CREAM ON THE FARM



DAIRYMEN lose millions of dollars annually because of poorly cooled milk and cream. These losses occur because the milk or cream is returned by dealers to the farmers, and because of low-grade manufactured products which bring low prices.

Every dairyman who produces and delivers a high grade of milk or cream raises the average quality of all the milk and cream with which it is mixed, and as a result a better product reaches the consumer.

Proper cooling is just as important with cream as with milk, especially as cream usually is delivered less frequently and therefore has greater opportunity to undergo undesirable fermentations. Proper cooling is easily done with little additional equipment and labor.

Natural ice can be had on the dairy farms that produce 80 per cent of this country's milk and cream supply. Even where ice is not available, milk and cream, by better use of available cooling facilities, may be cooled more effectively than at present.

Washington, D. C.

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COOLING MILK AND CREAM ON THE FARM

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NECESSITY FOR PROMPT COOLING

Cooling milk and cream on the farm promptly and properly would prevent to a very great extent the enormous waste which occurs every year. Milk dealers and manufacturers of dairy products often are obliged to return to the farmer milk or cream that is sour or about to become sour. Part of the returned milk is fed to livestock, but

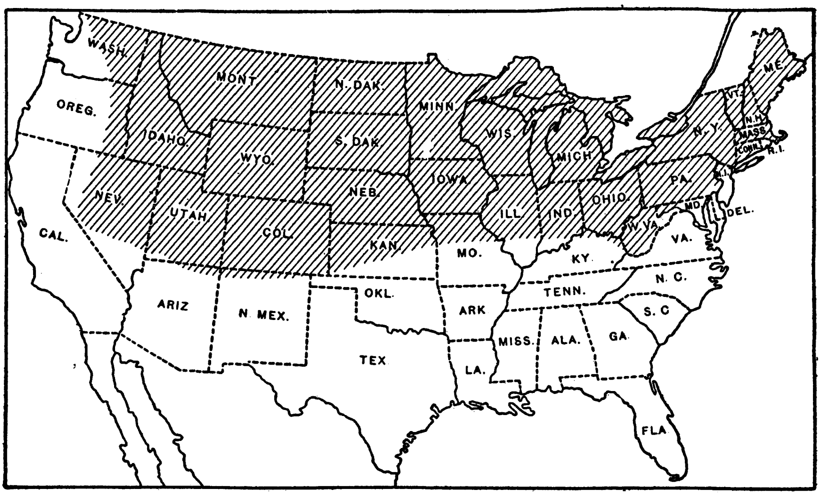

FIGURE 1.—Map of the United States, showing region of natural ice. More than 80 per cent of the milk and cream sold from farms in this country is produced in the shaded area

frequently the remainder is a total loss. In addition, some of the cream that is accepted by creameries is of poor quality and can not be manufactured into the best grades of butter.

More than 80 per cent of all the milk and cream sold from farms in the United States is produced in sections where natural ice can be harvested. (Fig. 1.) Therefore with the proper use of ice at least

[1] Original by J. A. Gamble, who resigned Aug. 31, 1918.

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80 per cent of the milk and cream can be cooled on the farm to a temperature so low that they will reach the dealer and the consumer in good condition. In order that milk and cream of high quality may be delivered, they must be cooled promptly and efficiently after each milking. The advantageous use of the cooling facilities which are available on almost every farm would result in great improvement in the quality of milk and cream at little if any additional cost.

DEVELOPMENT OF BACTERIA IN MILK

Milk as it leaves the udder of the healthy cow usually contains very few bacteria, but others are added through careless handling and improper methods of production. Bacteria multiply rapidly in warm milk and soon cause souring or other undesirable fermentation. No matter how clean and healthy the cows, how sanitary the methods, or how clean the utensils, milk will soon deteriorate in quality and contain many thousands of bacteria if it is not effectively cooled. Bacteria may get into milk from the stable air, but by far the greater number come from unclean and unsterilized utensils and the dust and dirt that fall from the flanks and udder of the cow during milking.

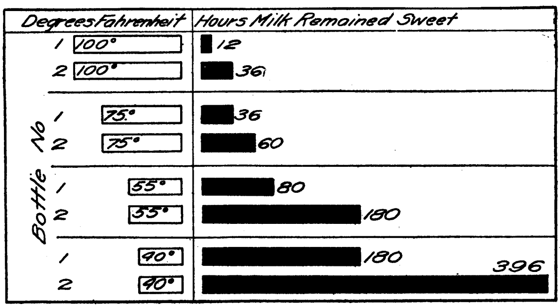

FIGURE 2.—Diagram showing time required to sour milk of high (1) and low (2) bacterial content at different temperatures

Bacteria grow and multiply much more slowly in cold than in warm milk. When drawn from the cow milk has a temperature a little above 90° F., a temperature at which bacteria grow very rapidly. The effect of temperature upon the development of bacteria is well illustrated by two samples of milk, one of which had 280,000 and the other 16,400 bacteria per cubic centimeter [2] at the time of plating. Each sample was divided into 4 parts, and the 8 parts were kept at certain temperatures to determine what length of time would elapse before milk soured. (Fig. 2.) The high-bacteria sample kept at a temperature of 100° F. soured in 12 hours, while the low-bacteria sample at the same temperature soured in 36 hours. When kept at 40° F., the high-bacteria sample soured in 180 hours, while the low-bacteria sample soured in 396 hours. The effect of low temperature in checking bacterial growth and multiplication is very evident.

If cooling is delayed, bacteria may develop rapidly and be present in large numbers, even though the milk is eventually cooled to a low temperature. On dairy farms where only a few men are employed, milk is often kept in the barn for an hour or more before being cooled. Under such conditions it may be several hours after the milk is drawn before it is cold enough to check the growth of bacteria.

[2] A cubic centimeter equals about 16 drops of water.

This condition is especially true when the water used for cooling is at a temperature of 55° F. or higher and ice is not used. Prompt cooling necessitates the immediate removal of milk from the barn to the place of cooling, which also is good practice, because it shortens the time that the milk is exposed to the air of the barn. Since, in general, bacteria multiply more slowly as the temperature is lowered, the more rapid the drop in temperature the less time for their multiplication and growth.

As now distributed, milk is from a few hours to as many as 72 hours old before it reaches the consumer. Bacteria, therefore, have plenty of time to grow and develop if conditions favor them. Milk that has not been cooled promptly spoils very quickly when warmed, as frequently happens in hot weather during transit from the farm to the city. It is not uncommon for the temperature of milk to rise 10 degrees between the time it is delivered to the consumer and the time it is placed in the ice box.

While cleanliness is the first essential in the production of milk and cream, prompt cooling and storage at low temperatures are the most important factors in preventing souring. For best results, milk and cream should be cooled immediately after milking and kept at a temperature low enough to check the growth of bacteria.

THE PRINCIPLE OF COOLING

Proper cooling of milk is easily accomplished. Water, perhaps the most common cooling agent, has been used for the purpose for centuries. When a can of warm milk is placed in cold water the heat passes into the water until the temperature of the two is about the same. The final temperature of both depends largely upon the relative volume and initial temperature of each. If a 10-gallon can of milk at a temperature of 85° F. is placed in a cooling tank containing 30 gallons of water at 37° F., the final temperature of both milk and water under average summer conditions will be about 50° F. (Fig. 3.) With twice the volume (or 60 gallons) of water of the same temperature the final temperature of the milk and of the water will be about 45° F. It is evident, therefore, that in order to cool milk to below 50° F. it is necessary to have the volume of ice water large compared with that of the milk.

USE OF SURFACE COOLERS

Water at a temperature of from 50° to 60° F. is available for cooling milk on most dairy farms. To obtain the most rapid, efficient, and economical cooling of milk use a surface cooler which is simple, durable, and easily cleaned and sterilized. In operating give special attention to regulating the flow of milk so that a continuous but thin stream will pass over the cooler, thus obtaining the maximum cooling effect. Cool each cow's milk immediately after milking, without waiting for all the cows to be milked. Surface coolers for running water can be used where there is sufficient water pressure, and other types can be used with ice water when running water is not available. Precooling, or cooling first with a surface cooler before placing the cans in the cooling tank, not only cools milk more rapidly but saves considerable ice. By this means the milk

may be cooled to within 2 or 3 degrees of the temperature of the cooling water.

Under average conditions, with a surface cooler and running water, from 10 to 15 gallons of water should be sufficient to lower the temperature of each gallon of warm milk to within 3 degrees of the initial temperature of the water. A great loss in cooling efficiency may result during warm weather if the water used for precooling is allowed to become warm before it is used. The warmer the water used for cooling, the more ice will be needed. In cooling 10 gallons of milk, a difference of 10 degrees in the temperature of the water between 50° and 60° F. is equal to the melting of approximately 5 pounds of ice, while the difference in temperature between 50° and 70° F. is equal to the melting of 10 pounds.

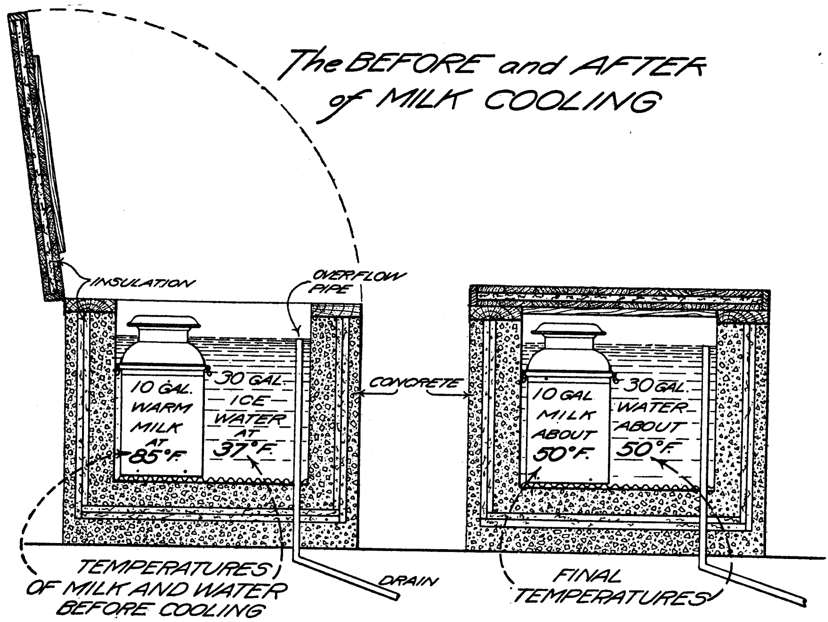

FIGURE 3.—Cross section of insulated concrete tank, showing cooling effect of water

When it is necessary to cool milk quickly to 50° F. or below, as when the morning's milk must be delivered shortly after milking, use ice water in the surface cooler, provided it is of a suitable type, instead of spring or well water, as these are seldom cold enough to cool milk below 50° F. In the case of the night's milk, when more time is available, cool to within 2 or 3 degrees of the temperature of the spring or well water by means of a surface cooler and then place the cans of milk in a tank of ice water to remain until time for delivery.

Satisfactory results through precooling depend very largely upon the care used. Objections have been raised to the use of surface coolers because sometimes they are improperly washed and sterilized and the cooling is done in a dusty room, with the result that the

number of bacteria in milk is increased. To prevent the increase in the number of bacteria wash the cooler, sterilize it very carefully, and protect it from dust by a metal cover.

SOME TYPES OF COOLERS

A type of plain conical cooler where the water and ice are placed inside the cone is shown in Figure 4. At the top is a bowl with a row of small holes around the lower rim, from which the milk flows over the cooling surface into the receiving can. This type is usually provided with an opening through which a stirrer may be placed for the purpose of agitating the ice water.

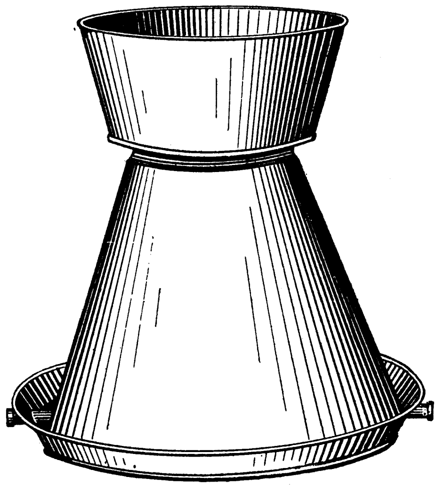

FIGURE 4.—Cone milk cooler for water and ice. To obtain good results with this cooler the water and ice must be stirred frequently

Figure 5 shows a type of spiral corrugated milk cooler in which the water, under pressure, enters through a pipe near the bottom into the inner space of the corrugations, and flows around and up, coming out at the top, where it flows into the outlet pipe. In this cooler the warmest milk comes into contact with the warmest part of the cooler, and as it flows down it comes into contact with the coldest surface. Above the cooler is a receiving bowl with a number of small holes around the outer edge of the bottom, through which the milk flows over the cooler. After passing over the corrugations the milk is caught in a trough at the bottom, through which it flows into the receiving can. With the above two types the flow depends upon the size of the holes and can not be regulated to meet varying conditions.

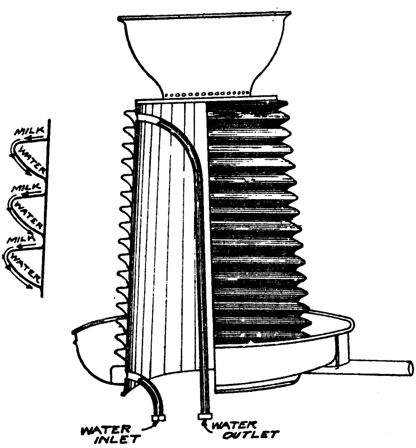

FIGURE 5.—Spiral milk cooler for running water

Another type of cooler is shown in Figure 6. In this apparatus cold water enters near the bottom, flows upward and out near the top, while the warm milk flows over both sides of the corrugation and is caught by a trough at the bottom, from which it passes to the receiving can.

MILK-COOLING TANKS

To cool milk efficiently and hold it at low temperatures a tank located in a milk house or specially constructed room is necessary in addition to a surface cooler. The object of the cooling tank is to complete the cooling and keep the milk cold. A well-constructed tank also helps protect the milk from flies and other insects, dust, foul odors, and other impurities, and if well insulated also protects milk from freezing in the winter.

A cooling tank that is durable and easily cleaned is easy to construct. Provide an adjustable overflow pipe to regulate the height of the water in the tank so that it will always be as high on the outside of the can as the milk is on the inside; otherwise the milk in that part of the can extending above the water line will not cool so rapidly as the milk below the water level. Thus the time taken

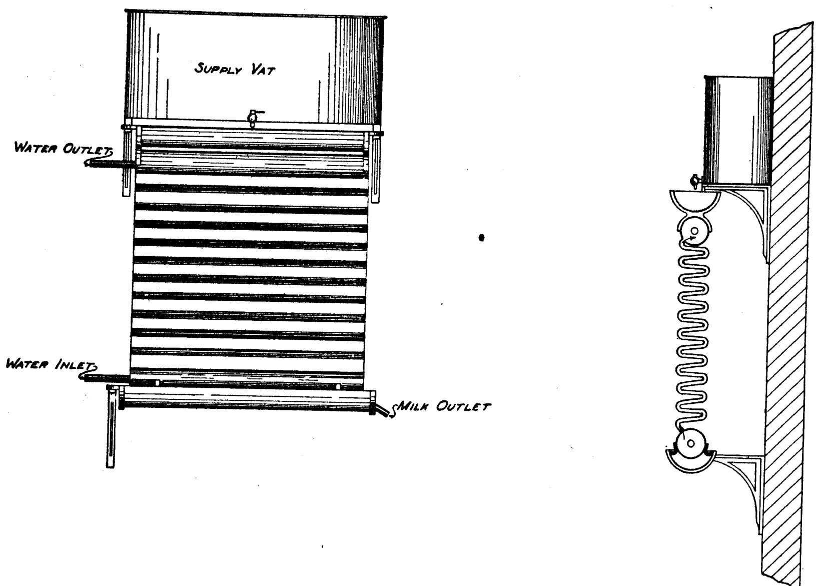

FIGURE 6.—Corrugated milk cooler for running water

to cool the can of milk is increased in proportion to the quantity of milk above the water line. Provide a drainage outlet in the bottom of the tank so that when cleaning is necessary the water may be drawn off. Many milk-cooling tanks in use are without such outlets and, being hard to empty, are seldom cleaned. Keep the tank clean and the water in it fresh and pure. Put some narrow strips in the bottom on which to set the milk cans in order that the water may flow both around and under them. When a concrete tank is used it is desirable to place boards or strips of iron on the edges of the tank to prevent chipping the top edges of the concrete as the cans are lifted in or out.

SIZE

The size of the cooling tank depends upon the quantity of milk to be cooled. Milk tanks are often too large to cool efficiently the

quantity of milk produced without wasting ice. In many cases, on the other hand, they are too small to permit the use of enough ice to cool the milk properly and to hold it at a low temperature. Half-barrels are sometimes used as tanks but are not suitable for the proper cooling of milk in an 8-gallon or a larger can. When such a can is placed in a half barrel with water there is not room for enough ice to cool and hold the milk at 50° F.

In order that the capacity of the tank may be adjusted to the milk supply it is advisable, when building, to divide the tank into two parts, the larger having about twice the capacity of the smaller. The larger part should hold a quantity of water sufficient to cool the ordinary quantity of milk. The smaller part is then available if the production should increase or may be used in case less milk is produced. In building, such arrangements can be made with but little additional cost.

A tank holding a little more than 4 gallons of water for each gallon of milk is more efficient than a larger one when precooling is not practiced.

LOCATION

Place the cooling tank in the milk house where it will be protected from the sun in summer and from excessive cold in winter. Tanks placed outdoors lose much of their cooling effect through absorption of heat from the air and they also deteriorate rapidly. On many farms the milk tank, like the farm pump, is exposed to the weather. When ice is so exposed in tanks, especially if of galvanized iron or uninsulated concrete, the losses through heat absorption during hot weather are very great.

USE OF ICE IN TANKS

Put ice into the cooling tank long enough before milking so that the tank water will be cold when the milk is ready to be cooled. The quantity of ice necessary for the proper cooling of milk produced on any farm can be determined by putting a definite weight of ice into the cooling tank and ascertaining, by means of a dairy thermometer, how much is necessary to cool milk to 50° F. or below and to keep it at that temperature.

When milk is first precooled over a surface cooler with water at temperatures of 50°, 55°, or 60° F., and the water in the cooling tank is at a temperature of 45° F. when the milk is placed in the tank, about 1½, 2, or 2½ pounds of ice will be required, respectively, to cool and hold each gallon of milk at 50° F. Without precooling, the water in the tank must be cooled to 45° F. and about 4 pounds of ice added for each gallon of warm milk to be cooled. In other words, practically double the quantity of ice is required when milk is not precooled.

EFFICIENCY OF DIFFERENT TYPES

On about 80 per cent of the farms that produce market milk in the United States some kind of tank is used for cooling milk. A survey of many thousand dairies showed that about 20 per cent of the cooling tanks were of metal, 25 per cent of wood, and 30 per cent of concrete, the remainder being of miscellaneous materials. Lower temperatures can be obtained and ice can be used more effectively in

wooden tanks than in plain concrete tanks. Very few tanks in use are insulated, and in very few cases is provision made to minimize the loss of cooling due to absorption. Where running water and plenty of ice are available it may be unnecessary to insulate the tank. Insulating either concrete or wooden tanks increases their efficiency, however, as it saves ice and has a greater cooling effect. The fact that insulated concrete tanks can be set partly in the ground helps to prevent radiation and permits the cans to be lifted in and out with comparatively little effort. An insulated concrete tank lasts longer, under similar conditions, than does a wooden or galvanized-iron tank.

The relative loss of cooling effect in different kinds of tanks expressed in pounds of ice melted is shown in Table 1.

The economy of an insulated tank and the importance of covering and shelter are very evident. The galvanized-iron tank, without cover and exposed to the sun, showed a loss of 168 pounds of ice, compared with only 7.6 pounds for the cork-insulated wooden tank properly covered and placed in the milk house. The saving by the use of a well insulated tank properly covered and protected would soon pay for any difference in the original cost.

TABLE 1.—*Quantities of ice which melted in 9 hours in each of 4 types of milk-cooling tanks under various conditions of exposure, when average outside air temperature was 84.2° F.*

Type of tank	Tanks, without covers, exposed to sun	Tanks, covered, exposed to sun	Tanks, without covers, in milk house	Tanks, covered, in milk house
	Pounds	*Pounds*	*Pounds*	*Pounds*
Galvanized-iron tank	168	111	107	84.0
Plain concrete tank	137	88	80	61.0
Wooden tank	107	38	50	30.5
Cork-insulated wooden tank	80	12	30	7.6

HOW TO BUILD AN INSULATED TANK

The total thickness of the walls of an insulated concrete tank should be 8 inches, divided into two walls, the outside being 2 inches, then 2 inches of good insulation, and the inside wall 4 inches thick. Make the concrete mix of 1 part Portland cement, 2 parts clean, sharp sand, and 4 parts broken stone or gravel. Add to the mixture a good grade of concrete waterproofing. Coat the insulation with and set it in hot asphalt. See that the asphalt is thoroughly dry before the inner walls of the tank are put up. Trowel the inside walls very carefully, and when the forms are removed brush the walls with a mixture of cement and water, mixed to the consistency of paint, so as to insure a smooth, nonporous surface.

USE OF WELL OR SPRING WATER FOR COOLING MILK

An arrangement for cooling milk either with or without ice is shown in Figure 7. Take special care to use the water at as low a temperature as possible. The water from the well may be pumped directly to the surface cooler and the milk-cooling tank. Water from the storage tank should be used only during very cold weather, when its temperature is colder than that pumped direct from the well.

When ice is not available, water pumped for the use of horses and other livestock should first flow through the milk-cooling tank. Place the inlet at the bottom so that the water flows in and around the milk cans and then out at the overflow near the top into the stock tank. When ice or running water can not be obtained, use from

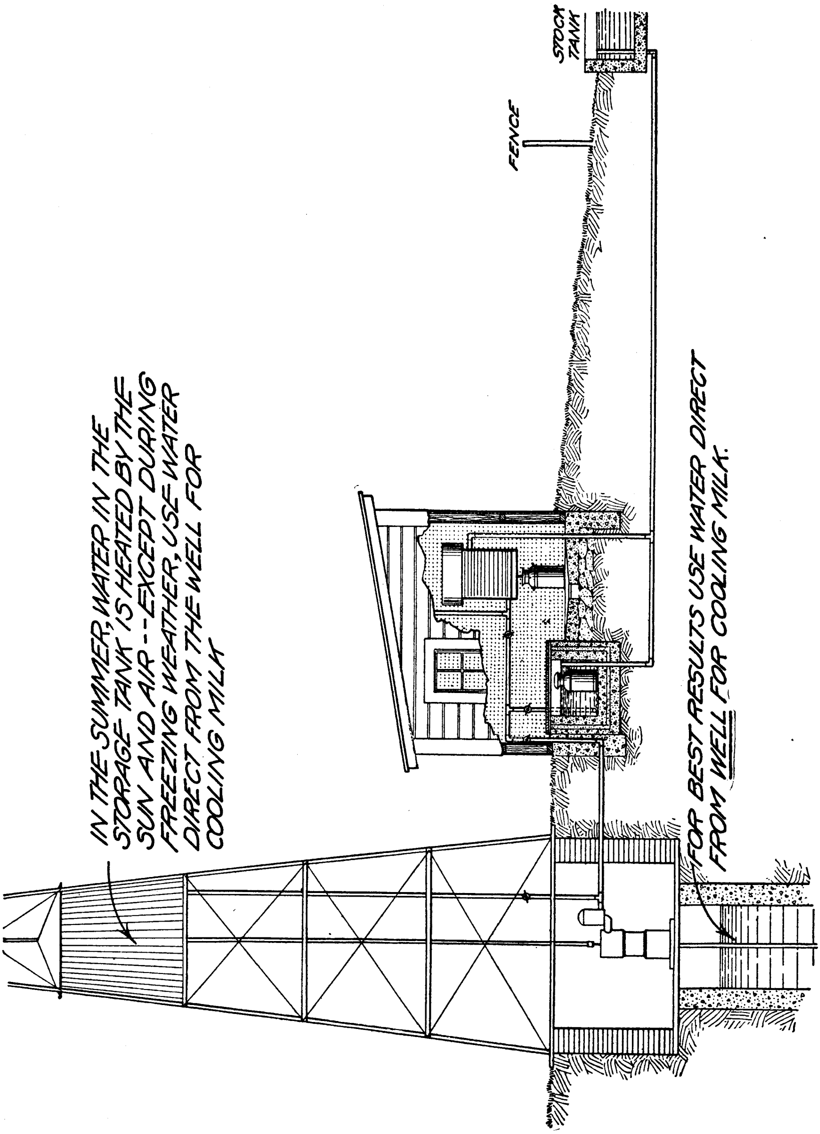

FIGURE 7.—Arrangement of water supply for milk house

6 to 10 gallons of water in the milk-cooling tank for each gallon of milk to be cooled and stored, and change the water in the tank frequently.

On many farms milk is cooled in springs or in tanks fed by springs. Water of that kind is seldom cold enough to cool milk promptly to 50° F. in hot weather. Unless the spring is protected from the direct

rays of the sun and from surface drainage, the temperature of the water is raised several degrees before it reaches the cooling tank. Spring water always should be carried to the cooling tank in a pipe laid several feet under ground. Instances have been known in which spring water has been warmed 20 degrees in flowing from the spring to the milk tank, whereas when properly conveyed its temperature should rise only a few degrees.

Spring water is seldom as cold as it is thought to be, and springs that are said to be "as cold as ice" frequently have a temperature as high as 65° F. An accurate thermometer is essential, therefore, to determine the temperature of the water for cooling milk.

USE OF MECHANICAL REFRIGERATION

Mechanical refrigeration has come into use on dairy farms where milk production is sufficient to warrant the expenditure or where special grades of milk or cream are produced. This type of equipment eliminates the labor of harvesting, storing, and handling ice. Much lower and more even temperatures can be maintained with this method of refrigeration. The initial cost of such equipment must be considered, together with the fact that it requires electric current, which is not always available in the rural sections.

KEEPING MILK COLD DURING SHIPMENT

Protect milk in transit from high temperatures. Under average conditions milk transported in cans during hot weather is usually several degrees warmer by the time it reaches its destination. On the railroad and motor trucks it is held from a few hours to all day; and unless shipped in cars especially equipped to maintain low temperatures or on trucks where necessary precautions are taken, there is a further rise in temperature. That is the case when milk is shipped in baggage cars or in milk cars not provided with ice. To make sure that milk reaches the city in the very best condition, cool it promptly to 50° F. or below on the farm and protect it during shipment. During hot weather chunks of ice scattered over the tops of the cans will help maintain the temperature of the milk. In the latest types of refrigerator cars milk is maintained at temperatures of about 40° F. in carload lots when precooled to that temperature before shipping. If the cars are opened at several stations to receive milk it is more difficult to maintain a low temperature.

SPECIAL CANS AND JACKETS

To illustrate the importance of protecting milk in transit during hot weather, four 10-gallon cans of milk cooled to 44° F. were hauled a distance of 13 miles from a farm to the railroad station. No. 1 was an insulated can, No. 2 was an ordinary unprotected can covered with a 1-inch felt jacket, No. 3 was covered with a half-inch felt jacket, and No. 4 was an ordinary unprotected can. During the trip the milk in the insulated can rose 1 degree, the milk in the cans protected with jackets rose 6 degrees, and the milk in the unprotected can rose 20 degrees. The cans were then shipped by rail in an ordinary baggage car for more than 1,000 miles at an average air temperature of

about 80° F. In the unprotected can the milk had reached a temperature of 60° F. when it had traveled about 10 miles from the farm (before reaching the railroad), the milk in the can covered with the half-inch jacket reached 60° F. after about 268 miles of travel, the can covered with the 1-inch jacket traveled about 332 miles before reaching 60° F., and the milk in the insulated can did not reach 60° F. until after 650 miles of travel. By the use of a half-inch jacket it was possible to ship an individual can of milk twenty-six times as far as in the ordinary can before the temperature rose to 60° F; the 1-inch jacket increased the distance to thirty-three times, and the insulated can sixty-five times that of the ordinary can.

Milk sours very rapidly at temperatures above 60° F., and therefore should be kept below that temperature, and preferably below 50° until used.

WINTER CARE AND HANDLING

Take care in winter to prevent the freezing of milk and cream. Keep them in a milk house or a specially constructed room. Where running water from a spring is available the problem of cooling and holding without freezing is easily solved by piping water to the milk house and allowing it to flow continually through the cooling tank. On farms where running water is not available, fresh water should be pumped into the tank just before placing the milk therein. Empty the tank as soon as the milk is removed. In transporting milk in cans for considerable distances by uncovered wagon or motor truck, cover it with a heavy blanket used only for that purpose so as to protect it from the extreme cold. Protection of milk and cream in transit is as important during the winter as it is in the summer.

HOW TO STOP MILK LOSSES

A large part of the annual loss from sour milk is due to the shipping of milk at too high a temperature. A survey of the temperature at which milk is received at railroad stations for shipment to market during the hot months showed the average temperature of morning's milk to be about 60° F., and in some cases it was as high as 80° F. These temperatures are much too high to permit milk to be shipped a considerable distance without souring.

When milk is not precooled and ice is not added to the tank until after the milk is placed in it, with the water supply at 70°, 60°, 55°, 50° F., the time needed to cool 10 gallons of milk to 50° F. is, respectively, about 2 hours and 25 minutes, 1 hour and 45 minutes, 1 hour and 30 minutes, and 1 hour and 20 minutes. The time required to cool milk to 50° F. by such methods is too long, especially when morning's milk must be delivered within a short time after milking. The result is that much milk reaches the shipping station in summer at so high a temperature that it sours on the way to the city.

When 10 gallons of milk, after having been precooled with water at 70°, 60°, 55°, and 50° F., were placed in water at the same respective temperatures, and ice was then added to the tank, it required 2 hours and 10 minutes, 1 hour and 15 minutes, 43 minutes, and 20 minutes, respectively, to cool the milk to 50 F. The precooling, with a surface cooler, of a 10-gallon can of milk with water at 70° F. saved

approximately 11 pounds of ice; with water at 60° F., 16 pounds of ice were saved; with water at 55° F., 19 pounds of ice were saved; and with water at 50° F., 22 pounds of ice were saved.

The best and quickest way to cool milk to 50° F. is to run it over a surface cooler with the coldest available water, set the cans of milk in a well-insulated tank, the water of which is below 40° F., and stir the milk frequently with a sterilized metal stirrer. Milk can be cooled by this method to 50° F. within an hour after it leaves the cow. A 10-gallon can of warm milk precooled with water at 55° F. and set in a tank of ice water at 37° F. was cooled to 50° F. in 20 minutes.

THE COOLING OF CREAM

In general the cooling rules laid down for milk may be applied to cream with equally good results. There are, however, some additional considerations. Milk should be separated so as to produce cream containing 30 to 35 per cent butterfat. Such cream sours more slowly than thin cream and makes less bulk to handle and transport, besides leaving more skim milk on the farm.

Cream should be cooled immediately after it is separated. Where there is sufficient volume, precooling over a small surface cooler and then setting the can in ice water is the best method to use. If only a small quantity is handled, it may be put, without precooling, into small cans, which can be placed in ice water and the cream stirred at regular intervals with a sterilized metal stirrer until the temperature has been lowered to 50° F. or less. Fresh cream should not be mixed with previous skimmings until it has been thoroughly cooled, as the addition of warm cream to cold hastens souring by warming the whole mass. As cream cools more slowly than milk, it is very important to use ice.

Remember that the separator parts should be washed and sterilized after each use.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

October 28, 1929

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